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8.	ABSTARCT	The forehand drive in tennis will continue to be one of the most frequently executed strokes during competitive play and is expected to play a pivotal role in determining match outcomes. Despite its critical importance, limited scientific analysis are available to explore the variables that influence its accuracy and effectiveness. This study will aim to bridge that gap by examining the relationship between selected anthropometric traits, skill-related fitness components, and kinematic variables, and their potential to predict forehand drive performance among elite male tennis players aged 18 to 25 years. A total of 30 right-handed national-level players will be assessed using standardized testing procedures, including Hewitt's Tennis Skill Test for accuracy. Anthropometric

		measurements such as height, weight, arm length, forearm girth, and leg length will be recorded along with skill-related metrics like grip strength, coordination, balance, shoulder strength, and leg power. Additionally, both angular and linear kinematic data will be collected using Kinovea software, and the accuracy of the stroke will be measured by speed gun technologies. The findings of this study will aim to support tennis coaches in talent identification, performance enhancement, and the design of training programs rooted in empirical evidence. By identifying key predictors of forehand performance, the study will contribute to a more scientific and data-driven approach to coaching in tennis.
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11.	ATTACH SYNOPSIS	Synopsis Attached

ANALYSIS OF DIFFERENT PERFORMANCE PARAMETERS AS A PREDICTOR OF FOREHAND DRIVE SHOT IN TENNIS

SHORT SYNOPSIS

Submit in partial fulfillment of the requirement of the degree of

DOCTOR OF PHILOSOPHY

to

Laxmibai National Institute of Physical Education, Guwahati
(Deemed to be University)

By

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Certificate

I hereby declare that the short synopsis "Analysis of Different Performance Parameters as a Predictor of Forehand Drive Shot in Tennis" being submitted in partial fulfillment for the requirement of Doctor of Philosophy in Physical Education under the faculty of Physical Education of Lakshmibai National Institute of Physical Education, NERC, Guwahati during the academic year 2021-2022.

It is a Bonafide record of original work carried out under the supervision of Dr. Hem Chandra Joshi and has not been submitted in full or part to any other university or institute for a degree or diploma. Further, it is certified that the short synopsis is plagiarism-free and the proof has been submitted.

29/4/2025

(Yash Sharma)

29/4/2025

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ABSTRACT

The forehand drive in tennis will continue to be one of the most frequently executed strokes during competitive play and is expected to play a pivotal role in determining match outcomes. Despite its critical importance, limited scientific analysis are available to explore the variables that influence its accuracy and effectiveness. This study will aim to bridge that gap by examining the relationship between selected anthropometric traits, skill-related fitness components, and kinematic variables, and their potential to predict forehand drive performance among elite male tennis players aged 18 to 25 years. A total of 30 right-handed national-level players will be assessed using standardized testing procedures, including Hewitt's Tennis Skill Test for accuracy. Anthropometric measurements such as height, weight, arm length, forearm girth, and leg length will be recorded along with skill-related metrics like grip strength, coordination, balance, shoulder strength, and leg power. Additionally, both angular and linear kinematic data will be collected using Kinovea software, and the accuracy of the stroke will be measured by speed gun technologies.

The findings of this study will aim to support tennis coaches in talent identification, performance enhancement, and the design of training programs rooted in empirical evidence. By identifying key predictors of forehand performance, the study will contribute to a more scientific and data-driven approach to coaching in tennis.

Keywords: Tennis, Forehand Drive, Anthropometric Variables, Skill-Related Fitness, Kinematic Analysis, Performance Prediction.

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1. INTRODUCTION

Sport involves the enjoyable pursuit of personal growth, self-realization, and the competitive application of both physical and mental abilities. The origins of sporting activities trace back to the earliest periods of human history. Physical fitness has been a crucial factor in human development over time. For instance, hunting an essential survival task in our evolutionary past demanded strong physical capabilities and effective collaboration. Those who excelled in these areas typically secured more or higher-quality food, which in turn enhanced their chances of survival. They reflect social values that can extend from individual values like discipline, asceticism, and self-control to collective values like sportsmanship and fairness, and generally accepted values like the belief in effort and productivity, the advantage of competition, and—following the logic of capitalism—the survival of the fittest. (D Beck, L Bosshart, 2003)

Tennis traces its origins back to 12th or 13th century France. In 1873, Major Walter C. Winfield introduced a version of the game in Great Britain, played on an hourglass-shaped court. By 1877, the All-England Croquet Club organized a tennis tournament using a rectangular court and rules that closely resemble those of the modern game. The sport rapidly gained popularity across America, Britain, and eventually spread globally. Tennis is a sport played on a rectangular court with marked boundaries, where competitors face off either one-on-one in singles or in teams of two during doubles, with a net positioned at the center dividing the two sides. The Davis Cup, launched in 1900, aimed to popularize tennis internationally. The International Tennis Federation (ITF) was officially founded on March 1, 1913."It formulates rules guidelines, equipment used, defines court dimensions to be followed by all the players participating in competitions throughout the world (Gillmeister and Heiner, 1998).

A tennis court is rectangular, measuring 78 feet (23.77 meters) in length. Its width is 27 feet (8.23 meters) for singles matches and extends to 36 feet (10.97 meters) for doubles. A net stretches across the center, supported by a cord or metal cable connected to two posts standing 3.5 feet (1.07 meters) high. At the midpoint, the net height is reduced to 3 feet (0.914 meters) using a central strap. The lines marking the ends of the court are known as baselines, while those along the sides are called sidelines. All measurements are taken from the outer edge of the lines, and the lines are marked in a color that contrasts clearly with the court's surface. (ITF, 2017).

Tennis is played using several key strokes, one of which is the forehand. In a forehand, the player faces the palm of their dominant hand forward while holding the racket. To execute the stroke, they swing the racket across their body toward the desired direction of the ball. The backhand, on the other hand, involves swinging the racket with the back of the hand leading, rather than the palm. While the term "backhand volley" refers to a specific type of shot, a backhand is typically a groundstroke, where the ball bounces before being hit. The serve is used to start every point, with the player striking the ball so it lands in the diagonally opposite service box while clearing the net. Players generally begin by tossing the ball into the air before hitting it.

Anthropometry refers to the structured method of measuring the human body. It began in the 19th century, primarily utilized by physical anthropologists to examine human differences and evolutionary patterns in both current and ancient populations. Traditionally, these measurements were used to associate bodily features with various racial, cultural, and psychological attributes. Specifically, anthropomorphic measurements involve the size (e.g., height, weight, surface area, and volume), structure (e.g., sitting vs. standing height, shoulder and hip width, arm/leg length, and neck circumference), and composition (e.g., percentage of body fat, water content, and lean body mass) of humans. (Johnston, 1982)

The anthropometric variable is very useful for physical educationists, coaches, and trainers to measure different parts and components of the human body. The scientific terminology for anthropometric is a word synthesized from two Greek words anthropos means man meter in means to measure the measurement of the human body (Devinder, 2008). Anthropometry identifies the body composition of the players of different sports, because the specific physical characteristics essential in many sports that indicate whether the player would be suitable to compete the highest level in specific sports (Reilly et al. 2001). The common perception of many athletes competes in sports appearance, attainment of an ideal body composition becomes a central theme of training in any sports to achieve an optimal body composition, and there may also be safety reasons (Ackland et al. 2003). Taller players had an advantage in playing ability over their peers in tennis (Yixiong et al. 2019). Height of the players associated with better ranking (Kumar, 2017).

Biomechanics is a key area in player development because all the strokes have a fundamental mechanical structure and sports injuries primarily have a mechanical cause (Elliott, 2006). Biomechanics is the science that examines the internal and external forces acting on a human body and the effects produced by these forces (Hay, 1993). Understanding sports biomechanics is essential for applying physics to athletic performance, as key physical concepts like motion, resistance, momentum, and friction influence nearly all sports activities. Analyzing technique involves examining how skills are executed, considering both the forces involved (kinetics) and the movement patterns (kinematics) (Lees, 2002; O'Donoghue, 2010). Kinematics, a branch of biomechanics, focuses on describing motion looking at factors such as the distance covered, speed, and consistency of movement. The latter aspect of motion is the preserve of kinetics a complementary branch of biomechanics (Hay, 1993).

Extensive quantitative biomechanical analyses are generally restricted to performance by elite athletes or clinical conditions. The parameter being calculated can be affected by the place and the process of taking biomechanical measurements. For measuring biomechanical variables a variety of tools are used. For example; timing system, video cameras, system for velocity-measurement and accelerometers all comes under the measuring tools used for measuring kinematic variables in biomechanics. Force platforms, pressure sensing devices, strain gauges, and electromyography are the tools for measuring kinetic variables in biomechanics. (McGinn, 2005). A kinematic evaluation is providing knowledge on the association of parts of the body to one another. This is helpful in measuring angles of joint throughout complicated movements and has given the general knowledge of functional actions that comes from kinematic assessments. (Trew & Everett, 2001) In order to be able to effectively analyse and improve technique, coaches today need a sound understanding of biomechanics. In diagnosis and correction of players, a good understanding of The main Biomechanical principles for tennis can be remembered easily by way of the acronym "BIOMEC". This stands for: Balance, Inertia, Opposite force, Momentum, Elastic Energy, Co-ordination chain. (Advanced Coaches Manual, 2007)

In India, Tennis is a popular sport, played by men and women almost in all states. Performance analysis and identifying performance characteristics associated with success are of great importance to players and coaches in any sport (Fitzpatrick et al. 2018). The forehand is a key

stroke in tennis and plays a crucial role in the modern game. During baseline exchanges, experienced players often rely on the forehand more than any other shot. When mastered, it can become a powerful offensive tool for players of all skill levels. This shot is often used to put the opponent under pressure and to dominate the point. (Advanced Coaches Manual, 2007). Tennis player has to have strength and technical abilities to execute an accurate and effective forehand.

As scholar I felt that a large number of tennis players perform forehand stroke without knowing the scientific background and the technical aspects of forehand stroke. The research scholar believes that there is gap of knowledge when it comes to forehand stroke in Tennis, if on which worked upon can contribute immensely in the field of physical education and also in tennis sports society. As the scholar himself is a player, coach and official in tennis and when he went through various studies in tennis, he found out that there are very less studies which have been conducted to predict the performance of forehand drive performance for accuracy and he also found out that there is a gap which need to be filled as Forehand Drive is a major ground stroke in tennis which helps a player to dominate the point which is constantly used during baseline rallies. Therefore on the basis of it scholar formulated the study "Analysis of Different performance parameters as a predictor of Forehand Drive shot in Tennis.

The Tennis match consists of a variety of strokes like Service, Forehand Drive, Backhand Drive, Overhead, Volleys, and Slice but in modern times Forehand drive is usually performed the most by advanced players as it helps a player to dominate the point during rallies. Therefore, the aim of this study is to find out the relationship between selected anthropometric, skill-related fitness, and kinematic variables with forehand stroke performance and also to predict forehand stroke performance based on the selected anthropometric, skill-related fitness and kinematical variables among tennis players.

2. LITERATURE REVIEW

The relevant studies found from various sources from the Internet sources are cited below.

Kramer, Huijgen, Elferink, & Visscher (2017) proceeded with a study on the prophecy of the junior elite tennis player's performance. Knowledge of the present and succeeding tennis performance helps in junior tennis players' development. A sum of 86 elite tennis player (junior)* {boys, n = 44; girls, n = 42} Under13 {aged: 12.5 ± 0.3 years}, and followed to Under16, carried out in this research. Age, maturity, and physical fitness, were calculated at Under13. Fundamental components which were carried down to analyses and excerpt four physical components from eight tests (SJ, CMJ as, 5&10 meter sprint, reverse, ball throwing, the (spider test), and medicine ball throwing overhead). The conceivable connection of "age, maturity, & the physical components; speed, lower body power, upper body power, and agility" with under13 & under16 tennis performance was noted down. Dutch national list was used to measure the performance of at Under13 and Under16. Tennis performance for girls and boys and their correlation variables, was taken solely for the Regression analysis. The correlation flanked by power of upper body and performance of tennis was found positive in Under13 Boys & in girls, the positive relationship flanked by maturation and power of lower body with tennis of tennis were found in under13. The tennis performance of the pre maturing players were found to be better (R2 is 15%). & in girls Under16, maturity correlation occurred with performance in tennis (13% R^2); post-maturing girls at Under13 had performed well again in tennis at Under16. Measurement of the best tennis players (juniors) at under13 is most significant for watching their improvement. The measurement of these elite tennis players does not predict their tennis performance after 3 years.

Roetert, Garrett, Brown & Camaione (1992) investigated how performance capabilities in young male tennis athletes correlate with stroke assessments and official USTA rankings. Eighty-three boys aged 8 to 12, who were ranked players, underwent tests measuring strength, speed, agility, and endurance. Their tennis abilities were evaluated through both ratings and video analysis of real matches, alongside their USTA standings. Findings revealed a notable relationship between stroke ratings and both sectional and national rankings, with stronger associations seen with national rankings (correlation values ranging from 0.57 to 0.68). Regression data showed that nearly half (47%) of the variation in national rankings could be attributed to forehand stroke performance. The study concluded that among various physical attributes, only agility appeared to have predictive value for ranking outcomes in this age group (mean age 11.62 ± 0.62 years). Other

physical characteristics showed no significant link to rankings, whereas tennis-specific skills like stroke technique proved to be reliable indicators of competitive success. Physical maturity may also play a role in differentiating skill levels among young male players.

Sheldon & Eccles (2003) carried out a study examining the physical and psychological factors that influence how adult tennis players perceive their own abilities. While it's known that motivation is closely linked to perceived skill in an activity, the elements that shape such perceptions in sports remain less understood. This research aimed to identify which physical and psychological traits contribute to self-assessed tennis ability. A total of 323 women and 143 men completed questionnaires assessing their self-perceived tennis abilities, official USTA ratings, evaluations of seven specific tennis strokes (e.g., serve and forehand), and their views on physical and mental competencies. The study emphasizes the importance of incorporating psychological self-assessments when evaluating sport-specific competence.

Yixiong et al. (2019) conducted a study to classify male tennis players into distinct groups based on personal and physical characteristics, and to pinpoint performance metrics that differentiate these groups. Data from 1,188 competitors in Grand Slam singles matches (2015–2017) was used, covering statistics such as height, weight, handedness, experience, and backhand type. The researchers then applied MANOVA and discriminant analysis to assess performance differences between these clusters using 29 match variables. Serve effectiveness, number of winners, net play, and physical performance emerged as key factors distinguishing the groups. Left-handed players formed the most consistent group in terms of performance, while taller players generally outperformed others except at Roland Garros, where left-handers had an edge on the slower surface. At Wimbledon and the US Open, players in the medium-sized, right-handed, one-handed backhand group showed superior net and physical play. These insights enhance our understanding of performance trends and strategic planning across various player profiles.

Sattler et al. (2015) examined the relationships between body measurements, composition, jumping ability, strength, balance, and change-of-direction speed (CODS) as well as reactive agility in athletes. The research involved a total of 73 college-level athletes, comprising 39 males (with an average height of 182.95 ± 5.19 cm and weight of 80.66 ± 7.69 kg) and 34 females (with

an average height of 171.45 ± 6.81 cm and weight of 61.95 ± 6.70 kg), all approximately 22 years old. The assessed parameters included body mass, stature, body fat percentage (BF%), balance stability index, countermovement jump (CMJ), reactive strength index (RSI), and agility performance. Athletes were categorized into performance groups based on CODS achievements. Significant group differences were observed in CMJ (F = 3.45 and 3.60 for males and females), RSI (F = 6.94 and 5.29), and balance (F = 3.47) for men. For women, differences in RSI (F = 6.46), CMJ (F = 4.35), and BF% (F = 4.07) were noted, with canonical analysis (R = 0.74, p = 0.05) supporting these findings. The results underline the importance of separately training and assessing CODS and reactive agility to optimize athletic performance.

3. DESCRIPTION OF BROAD AREA

Operational Definitions

Forehand (Groundstroke)

The tennis forehand is a stroke where the palm of the dominant hand holding the racket faces forward. Essentially, it involves swinging the racket across the body toward the target area where the player intends to place the ball. (https://www.tennisct.com/strokes)

Kinanthropometry

Kinanthropometry is the study of human body size, shape and form and how those characteristics relate to human movement and sporting performance (Eston and Reilly, 2009).

Skill Related Fitness

The skill-related fitness variables are used to measure motor ability, motor fitness, and sports skill (Yobu, 2010).

Kinematics

“Kinematic is that branch of biomechanics which is concerned with describing the motion of bodies. Thus kinematic deals with such things as how far a body moves, how fast it moves, and how consistently it moves. It is not concerned at all with what causes a body to move the way it does.” (Danica, 2018)

Significance of the Study

1. The results of the study will help the tennis coaches to predict forehand stroke performance and identify the potential talent.
2. The study's findings will help coaches recognize the strengths and weaknesses in forehand stroke performance.
3. The results of the study will also help the tennis coaches to design suitable training program to improve the tennis forehand stroke performance.
4. The present research study will be helpful to coaches in selecting potential tennis players.
5. The results of the present study will help to design innovative training methods to improve forehand stroke performance.
6. The finding of the study will also help the coaches to identify errors while teaching forehand drive to fresher.

4. OBJECTIVES OF THE STUDY

4.1 PROBLEM STATEMENT

Modern tennis features a diverse range of strokes such as the service, forehand drive, backhand drive, overhead, volleys, and slice. Among these, the forehand drive has become increasingly prominent in contemporary play, particularly among advanced players, due to its role in asserting control during rallies. In light of this, the present study seeks to examine the correlation between specific anthropometric traits, skill-related fitness components, and kinematic factors with the execution of the forehand stroke. Additionally, the study aims to develop a predictive model for forehand performance using these selected variables in tennis players.

4.2 RESEARCH OBJECTIVES

1. To measure the forehand stroke performance for accuracy among elite tennis players.
2. To assess specific anthropometric characteristics—namely height, weight, arm length, forearm girth, and leg length—among top-level tennis players.
3. To measure the selected skill related fitness variables such as grip strength, dynamic balance, co-ordination, shoulder strength and leg power among elite tennis players.
4. To measure angular and linear kinematic variables, including joint angles (right ankle, knee, hip, shoulder, elbow, wrist) and ball speed, direction, and center of gravity height at contact in elite tennis players.
5. To find out the relationship between forehand stroke performance and selected anthropometric, skill related fitness and biomechanical variables among elite tennis players.
6. To predict the forehand stroke performance among elite tennis players based on selected anthropometric, skill related fitness and kinematic variables.

4.3 RESEARCH QUESTIONS

1. Whether there is a significant relationship of anthropometric variables with the accuracy of Forehand drive in Tennis?
2. Whether there is a significant relationship of skill related fitness variables with the accuracy of Forehand drive in Tennis?
3. Whether there is a significant relationship of kinematic variables with the accuracy of Forehand drive in Tennis?
4. If relationship exist among anthropometric, skill related fitness and kinematic variables with forehand drive performance for accuracy then which are the most contributing parameters in terms of anthropometric variables, skill related fitness variables and kinematic variables as a predictor of successful forehand drive in Tennis?

4.4 DELIMITATIONS

1. The study will be delimited to total 30 elite male tennis players from various clubs, academies, institutions who have represented national level competitions.
2. The age group of the subjects will range from 18 to 25 years.
3. The study will be further delimited to only right-hand players.
4. The study will be further delimited to forehand drive performance for accuracy which will be assessed by Hewitt's Tennis skill test.
5. The study will be further delimited to the subject whose competition age will range from 5 to 10 years.
6. The dependent variable of the study will be forehand drive performance for accuracy in Tennis. The independent variables of the study are as follows:

Anthropometric Variables

i. Height
ii. Weight
iii. Arm length
iv. Forearm Girth
v. Leg length

Skill related Fitness Variables

i. Grip Strength
ii. Dynamic Balance
iii. Co-ordination
iv. Shoulder Strength
v. Leg Power

Kinematic Variables (Angular)

i. Angle at right ankle joint.
ii. Angle at right knee joint.
iii. Angle at right hip joint.
iv. Angle at right shoulder joint.
v. Angle at right elbow joint.

vi. Angle at right wrist joint.

Kinematics Variables (Linear)

i. Speed of the ball
ii. Direction of the ball
iii. Height of center of gravity at the time of contact.

4.5 HYPOTHESES

1. It is proposed that a meaningful correlation exists between tennis forehand drive performance and specific anthropometric characteristics, including height, body weight, arm length, forearm circumference, and leg length.
2. It is proposed that tennis forehand drive performance is significantly associated with selected components of skill-related fitness such as grip strength, dynamic balance, coordination, shoulder strength, and lower limb power.
3. It is proposed that there will be a notable relationship between tennis forehand drive performance and selected kinematic variables, both angular and linear.
4. It is hypothesized that there will be a significant regression model to predict Forehand drive performance for accuracy on the basis of anthropometric variables, skill related fitness variables and kinematic variables.

5. RESEARCH METHODOLOGY

This chapter describes various techniques, methods, tests and measurement that will be required to obtain the necessary data. Great care will be taken in choosing the sampling design, research design, methods, tests and collection of data.

5.1 SELECTION OF SUBJECTS

Total thirty (N=30) male elite tennis players who had represented nationals and interuniversity competitions will be selected as the subjects of the study. Subjects will be selected from various tennis clubs, academies, colleges and universities by using random sampling method. All the selected players will be right handed for maintaining the purpose of homogeneity. The age of the

subjects will range from 18 to 25 years. Subjects who are injury free will be selected for this study. All the subjects will have an experience of forehand drive techniques and their competition age will range between 5 and 10 years.

5.2 SELECTION OF VARIABLES

Dependent variable

The forehand drive performance for accuracy will be selected as the dependent variable of this study.

Independent variable

The research scholar had undergone a lot of scientific literature, reviews, journals, and books and had a discussion with guide and experts to find out the research gap and identified the following independent variables pertaining to the study.

Anthropometric Variables

a) Height
b) Weight
c) Arm length
d) Forearm girth
e) Leg length

Skill Related Fitness Variables

a) Hand grip strength
b) Dynamic balance
c) Co-ordination
d) Arm power
e) Leg power

Kinematic Variables

Angular kinematics:

a) Angle at right ankle joint.

b) Angle at right knee joint.

c) Angle at right hip joint.

d) Angle at right shoulder joint.

e) Angle at right elbow joint.

f) Angle at right wrist joint.

Linear kinematics:-

a) Speed of the ball

b) Direction of the ball

c) Height of Centre of Gravity at the time of contact

CRITERION MEASURES

S. NO	Variables	Test/Equipment	Unit of Measurement
INDEPENDEDNT VARIABLES			
Anthropometric Variables			
1.	Height	Stadiometer	Centimeters
2.	Weight	Weighing Machine	Kilograms
3.	Arm Length	Measuring Tape	Centimeters
4.	Forearm Girth		
5.	Leg Length		
Skill Related Fitness Variables			
5.	Hand Grip Strength	Hand Dynamometer	Kilograms
6.	Dynamic Balance	Bass Dynamic Test	Number/Scores
7.	Co-ordination	Wall Pass	Number/Scores
8.	Shoulder Strength	Medicine Ball Throw	Meters

9.	Leg Power	Sargent Vertical Jump	Centimeters
Kinematic Variable			
Angular Kinematics			
10.	Angle at right wrist joint	Kinovea Software	Degree
11.	Angle at right elbow joint		
12.	Angle at right shoulder joint		
13.	Angle at right hip joint		
14.	Angle at right knee joint		
15.	Angle at right ankle joint		
Linear Kinematics			
16.	Direction of the ball	Kinovea Software	Centimeters
17.	Height of Centre of gravity at the time of contact		
18.	Speed of the Ball	Radar Speed Gun	kilometers per hour

5.3 DATA RELIABILITY

To maintain uniformity in scoring the chosen variables, the researcher consulted with both the supervisor and subject experts, gaining sufficient practice in administering the tests. A group of 10 participants will be selected and assessed using a test-retest approach on the identified variables. To determine the reliability of these variables, Pearson's product-moment correlation method will be applied. The study will utilize only standardized tools sourced from well-known and credible manufacturers, minimizing the risk of instrument-related errors. All equipment will be procured from established and trusted sources to ensure accuracy and suitability for the study's objectives. Since precise data collection is a key goal of the pilot study, consistent methods will be refined through repeated trials. Once the best-suited procedures are identified, the main study will adopt the finalized tests, measurements, and analysis techniques. The test-retest method will again be employed to verify the reliability and eliminate any minor inconsistencies arising from potential procedural issues. As a result, the study aims to gather highly dependable data, leaving no room for doubt regarding its credibility.

5.4 ADMINISTRATION OF TEST AND COLLECTION OF DATA

Hewitt's Forehand Drive Test

Forehand Drive Test Items: Each subject will be allowed 10 mins warming up time on the court. The subjects will be given a demonstration. After the demonstration, a subject will be asked to stand behind the baseline area and will be asked to perform a forehand drive with accuracy so as to make the ball pass above the net and below the 7-foot high restraining rope so as to attempt to place the ball at best scoring zones across the net. Each subject will be given five trials for forehand drive performance for accuracy.

Forehand Drive Test Item Area and Directions: With service line as one of the line for the test, three chalk lines will be drawn 4 and half feet apart between the service line and the baseline with point value for each zone. A quarter-inch rope will be stretched above the net at a height of 7 feet. The subjects will stand at the center of baseline. With a basket of ball, the instructor will take a position across the net at the intersection of the center line. The ten trials will be given for the forehand drive. The students will try to hit the ball between the net and rope so that the ball goes deep into the court. The same instructor will hit to all students to standardize the testing as much as possible. The point values for the scoring zone in which the forehand trials hit will be recorded. Balls that pass over the rope will receive half the point values of the respective zone.

Procedure of Measuring Speed of Service

The researcher will position themselves directly behind the subject, holding the Bushnell Speed Gun aimed at the ball's trajectory. As the subject will perform forehand drive, the scholar will squeeze the trigger of the speed gun. The readings will be recorded in kilometers per hour.

Fig. – 1

Bushnell Speed Gun

Procedure for Measuring Selected Angular Kinematics

The chosen kinematic variables including the angles at the right ankle, knee, hip, shoulder, elbow, wrist joints, and the racquet's angular speed were measured using Kinovea software..

Procedure for Measuring Selected Linear Kinematics

The identified kinematic variables ball speed, ball direction, and the center of gravity height at the point of contact will be determined using Kinovea software.

Procedure for Location of Centre of Gravity

Once the video footage is recorded, it will be analyzed using Kinovea Software version 0.8.25. The final posture in each identified phase will be displayed on-screen and paused at the appropriate

moment. Stick figure representations of all key movements including the Ready Position, Preparatory Phase, Point of Contact, and Follow Through will be captured as still images and stored for every participant. Additionally, the software will be used to calculate the center of gravity for each subject's full body.

Procedure for Measuring Selected Anthropometric Variables

The chosen anthropometric measurements such as Standing height, Weight, Arm length, Forearm girth, and Leg length will be obtained by measuring stadiometer, digital weighing machine, measuring tape, marker pen, writing pad, pen, pencil, and score sheet.

Standing Height

The subject will be asked to stand straight. The subject weight will be equally distributed on both feet. The subject will be instructed to look straight. The standing height will be recorded to the nearest 0.1 cm.

Fig. 2

Stadiometer

Weight

The weight will be measured with minimal clothing. The weighing machine will read zero then the subject will stand on the core of the weighing machine without any assistance and with the weight equally divided on both feet. Weight will be measured to the nearest 0.1 kilograms.

Fig. 3

Weighing Machine

Arm Length

The participant will stand in a relaxed upright position with arms naturally resting at the sides and fingers extended. The measurement will be taken on the right arm, starting from the acromion process of the scapula down to the tip of the middle finger. Arm length will be recorded with a precision of up to 0.01 centimeters.

Forearm Girth

The participant will be instructed to stand in a relaxed posture with their arms naturally resting by their sides and fingers extended. Measurements will be conducted on the right side of the body. The participant will then raise their arm with the palm facing upward, and the circumference will be measured around the forearm at its widest point.

Leg Length

The subject will be asked to stand with feet together and the lateral aspect of their right leg will be used to measure. The leg length will be measured from the greater trochanter of femur to the standing surface. Starting edge of the measuring tape will be placed on the marked greater trochanter of femur and the finishing edge of the measuring tape will be placed on the floor of the standing surface. Leg length will be measured to the nearest 0.01centimeters.

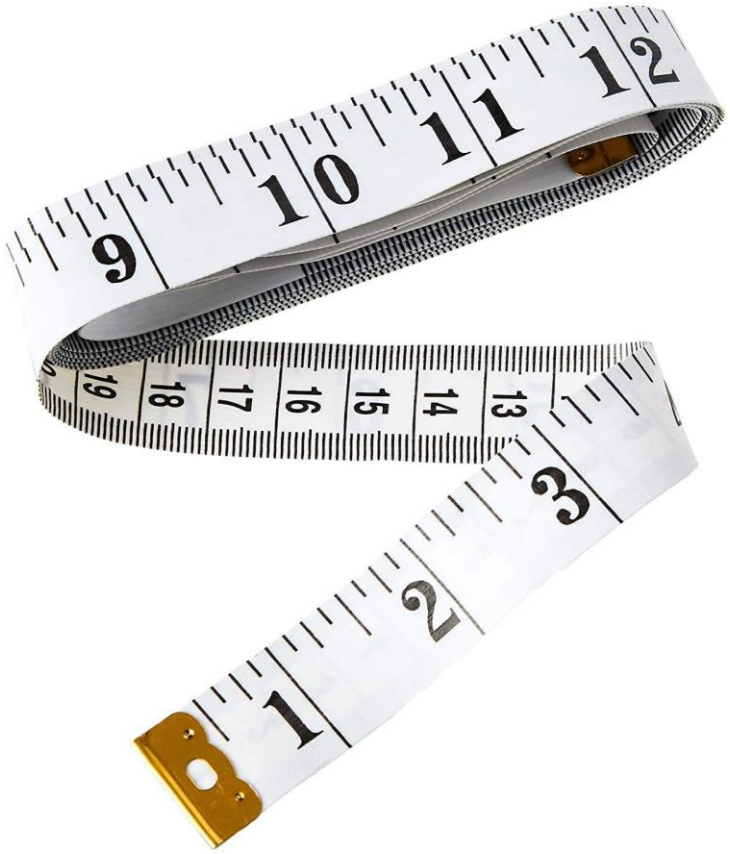

Fig. 4

Measuring Tape

Procedure for Measuring selected Skill Related Fitness Variables

Hand grip strength

The subject will be asked to hold the dynamometer in his right hand. The handle of the dynamometer will be adjusted based on the hand span. The hand grip dynamometer will be placed between the heel of the palm and the middle of the fingers. Then the subject will be asked to put maximal effort and to maintain the hold for 5 to 8 seconds. The best result from three trials will be recorded. 15 seconds of recovery will be given between each effort. The grip strength will be measured to the nearest 0.1 kilograms.

Fig. 5

Dynamometer

Dynamic Balance

The selected subject will be asked to stand stationary on the starting point square. Next, participants will be instructed to hop onto the first square using the ball of their left foot and maintain a stable, static position for five seconds. Following this, they will hop onto the second square with the ball of their right foot and again hold a steady posture for five seconds. This pattern of alternating foot hops and five-second static holds at each square will be repeated until the entire test sequence is finished. Five points will be given if the test performer successfully lands on the designed square correctly. One point will be given for each second the test performer successfully maintains his balance while on the ball of the foot on each designated square.

Co-ordination

The participant will be positioned approximately two meters from a flat wall. They will be instructed to throw a tennis ball using their right hand, aiming it at the wall, and catch it with their left hand. Then, they will throw it with their left hand and catch it with their right hand. This alternating pattern of throwing and catching will continue for a period of 30 seconds. The total number of successful catches made within this time frame will be recorded as the final score.

Shoulder Strength

The subject will be asked to stand behind the line in ready position. The 3kg medicine ball will be held in the right hand at the shoulder level. Then the subject will be asked to throw the ball vigorously forward as far as possible. The subject will be permitted to step forward over the line after the release of the ball. Three attempts will be allowed and the best one will be counted as a final score. The distance from the starting line to ball landing point will be recorded. The distance will be measured to the nearest 0.01 meters. The best of three trials will be recorded as the final score.

Leg Power

The selected subjects will be asked to stand near to the smooth wall. Then the subjects will be asked to elevate their right hand as high as possible to mark the fingertip level on the wall. Then, without moving their feet, subjects will squat and jump as high as possible, making another mark with his fingertips at the wall as high as possible. The best of three trials will be recorded as the

final score. The difference between the standing reach and the highest point of the jump will be recorded as a score. The jump distance will be measured to the nearest 0.01 centimeters.

5.5 Statistical Procedure

Statistical analysis will be carried out using the Statistical Package for Social Sciences (SPSS) version 20.0. To examine the extent to which forehand drive accuracy can be predicted based on anthropometric measurements, skill-related fitness factors, and kinematic variables, multiple regression analysis will be applied. The significance level for hypothesis testing will be established at 0.05.

6. EXPECTED OUTCOME

The anticipated findings of this study are expected to offer valuable insights for tennis coaching and player development. By establishing a clear relationship between selected anthropometric, skill-related fitness, and kinematic variables with forehand drive performance, the study will enable coaches to make informed predictions about an athlete's potential in executing this key stroke. It is also expected that the results will help identify individual strengths and limitations in forehand technique, allowing for more targeted and personalized coaching strategies. Furthermore, the study will contribute to the development of evidence-based training programs aimed at enhancing forehand accuracy and effectiveness among competitive players. Coaches may also utilize the outcomes to better recognize and nurture emerging talent, ensuring early intervention and skill refinement. Additionally, the findings could support the creation of innovative instructional approaches that simplify the teaching process for beginners while addressing common technical errors. Overall, the study will serve as a practical tool for optimizing forehand performance and improving overall training efficacy in tennis.

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